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Reclassification of *Schizocodon soldanelloides* var. *minimus* (Diapensiaceae)

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The taxonomic status of *Schizocodon ilicifolius* var. *minimus* (Diapensiaceae) on Yakushima has been debated over the last century. The phylogenetic relationships of *Schizocodon* were recently resolved using molecular markers; the analysis suggested that *Sc. ilicifolius* var. *minimus* should be reassigned to *Sc. soldanelloides*. We examined specimens of *Sc. ilicifolius* var. *minimus* from Yakushima and concluded that they were morphologically identical to *Sc. soldanelloides*. We therefore accept the combination *Schizocodon soldanelloides* var. *minimus* (Makino) H.Hara for this Yakushima endemic.

Key words: reclassification, *Schizocodon*, Yakushima

Schizocodon Siebold et Zucc. (Diapensiaceae) comprises two species, *Schizocodon soldanelloides* Siebold et Zucc. and *Sc. ilicifolius* Maxim. According to a recent classification proposed by Yamazaki (1993), these species comprise seven varieties. One of the varieties, *Sc. ilicifolius* var. *minimus* (Makino) T. Yamaz., is endemic to Yakushima where it is restricted to altitudes above 1700 m. It is a perennial dwarf herb. The taxonomic status of this variety has been debated over the last century (Table 1).

Makino (1912) first described these plants as *Shortia soldanelloides* (Siebold et Zucc.) Makino f. b. *minima* Makino. Makino & Nemoto (1925) accepted this taxonomic treatment. Masamune (1929, 1930), however, first considered these plants to be a variety of *Sh. soldanelloides* (Siebold et Zucc.) Makino and renamed them *Sh. soldanelloides* (Siebold et Zucc.) Makino var. *minima* (Makino) Masam. He (Masamune 1932) then recognized them at specific rank as *Sh. yakusimensis* Masam. Subsequently, they were transferred to *Schizocodon* by Honda (1939), who named them *Sc. soldanelloides* Siebold et Zucc. f. *minima* (Makino) Honda. Hara (1948) also recognized these plants as *Sc. soldanelloides*, but treated them at the rank of variety, *Sc. soldanelloides* Siebold et Zucc. var. *minimus* (Makino) H.Hara. Although Ohwi (1965) accepted *Sh. soldanelloides* var. *minima* (Makino) Masam., Yamazaki (1968) recognized them as *Sc. ilicifolius* var. *minimus* (Makino) T. Yamaz. Yamazaki's treatment has been widely accepted in the academic literature (e.g., Yahara *et al*. 1987, Yamazaki 1990, 1993) and in an illustrated encyclopedias (e.g., Yamazaki 1981).

Higashi *et al*. (2013) determined the phylogenetic position of *Schizocodon* based on amplified fragment length polymorphism (AFLP) analyses of 180 individuals from 48 populations. In their analysis, *Sc. ilicifolius* var. *minimus* were robustly clustered with individuals of *Sc. soldanelloides*. Membership in this clade was incongruent with the current classification.

Yamazaki (1968) claimed that *Schizocodon* on Yakushima was a variety of *Sc. ilicifolius*

TABLE 1. Taxonomic status of *Schizocodon soldanelloides* var. *minimus* over time.

Author	Described name
Makino (1912)	*Shortia soldanelloides* (Siebold et Zucc.) Makino f. b. *minima* Makino
Makino & Nemoto (1925)	*Shortia soldanelloides* (Siebold et Zucc.) Makino f. b. *minima* Makino
Masamune (1929, 1930)	*Shortia soldanelloides* (Siebold et Zucc.) Makino var. *minima* (Makino) Masam.
Masamune (1932)	*Shortia yakusimensis* Masam.
Honda (1939)	*Schizocodon soldanelloides* Siebold et Zucc. f. *minima* (Makino) Honda
Hara (1948)	*Schizocodon soldanelloides* Siebold et Zucc. var. *minimus* (Makino) H.Hara
Ohwi (1965)	*Shortia soldanelloides* (Siebold et Zucc.) Makino var. *minima* (Makino) Masam.
Yamazaki (1968, 1990, 1993)	*Schizocodon ilicifolius* Maxim. var. *minimus* (Makino) T.Yamaz.
Yahara *et al*. (1987)	*Schizocodon ilicifolius* Maxim. var. *minimus* (Makino) T.Yamaz.

based on the shape of the leaf blade and habitat (rocky areas) and reported (Yamazaki 1993) the leaf blade length and width to be within the range of 5–15 mm and with 1 or 2 inconspicuous teeth on the leaf margins. In addition, Yamazaki (1981) reported the leaf apex of *Sc. ilicifolius* to be acute and much higher than the tip of the nearest serration; the leaf apex of *Sc. soldanelloides* is acute and at about the same height as the tip of the nearest serration. Furthermore, in *Sc. ilicifolius*, Yamazaki (1993) reported the lateral nerves to be "scattered, more or less straight-ascending" while in *Sc. soldanelloides* "the lower lateral nerves meet at the midrib near the base." Yamazaki (1993) also described the shape of the staminode apex to be obtuse in *Sc. ilicifolius* but acute in *Sc. soldanelloides*. In the present study, we investigated these traits in *Schizocodon* in collections from Yakushima with an aim toward resolving their classification.

Materials and Methods

We examined specimens of *Schizocodon* from Yakushima Island in the herbaria at TI, KYO, and TNS. One hundred and five leaves from 57 individuals on 21 specimens were used for leaf blade analysis. We examined (with permission) the morphology of the staminodes of two individuals housed in KYO.

Results and Discussion

Figure 1 shows the leaf morphological traits of *Schizocodon* from Yakushima. The leaf blade length (longitudinal) ranged from 5–21 mm (mean ± standard deviation: 9.9 ± 3.1) and width (horizontal) ranged from 4–20 (8.6 ± 3.0) mm (Table 2). The teeth were inconspicuous. There were no paired teeth in 7 leaves, one tooth on 32 leaves, two teeth on 42 leaves, three teeth on 17 leaves and four teeth on 7 leaves. Yamazaki's (1993) descriptions of leaf blades 5–15 mm in length and width, with 1 or 2 inconspicuous teeth in the variety and our own findings overlap with the description given for *Sc. soldanelloides* f. *alpinus* Maxim., which has leaf blades 10–20 mm long. Each blade in *Sc. soldanelloides* f. alpinus has 3–5 minute inconspicuous teeth (Yamazaki 1993), suggesting that these characteristics are not taxonomically informative.

The apex of the leaf of the Yakushima plants was not much longer than the tip of the nearest serration (Fig. 1). These features match the traits of *Schizocodon soldanelloides*. The shallow teeth of variety *minimus* (Fig. 1) are also consistent with Yamazaki's (1993) description of "obtuse apiculate shallow teeth" in *Sc. soldanelloides*. The shape of the serrations is concordant with Yamazaki's (1981, 1993) description of *Sc. soldanelloides*, indicating that plants of *Schizocodon* on Yakushima are identical to *Sc. soldanelloides*.

The nerve pattern of the leaves of the Yakushima plants are shown in Fig. 1. c–e. The lateral nerves meet at the midrib, but we were unable to determine whether the lateral nerves of the insular plants are similar to those of either *Schizocodon soldanelloides* or *Sc. ilicifolius*.

We determined that the apex of the staminodes in the Yakushima plants is acute (Fig. 2), which matches the apex in *Schizocodon soldanelloides* (Yamazaki 1993).

TABLE 2. Morphological variation in leaves (width and length) in plants of *Schizocodon* from Yakushima.

Leaf blade width (mm) \ Leaf blade length (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1																						
2																						
3																						
4					3	3																
5					2	6	2															
6						1	2	6	1													
7							3	10	1													
8								4	4	4	1											
9									3	8	4	2										
10										1	2	3		1								
11										1	2	3	4	1		2						
12										1		1	2									
13													2	3		2						
14														1								
15															1							
16																						
17																			1			
18																						
19																						
20																					1	

Number indicates number of leaves and their width and length.

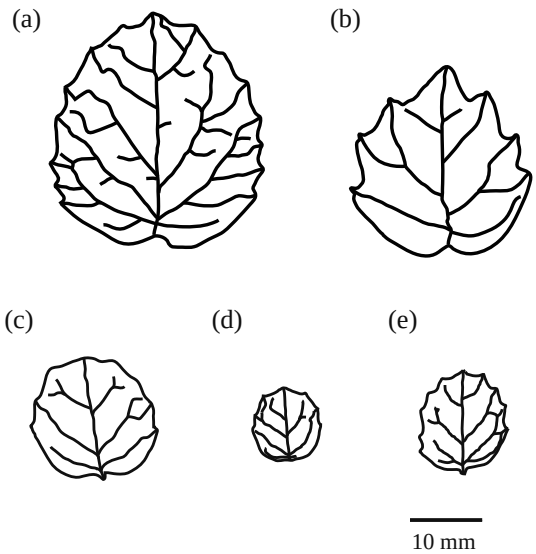

FIG. 1. Leaf morphology of (a) *Schizocodon soldanelloides* var. *soldanelloides*, (b) *Sc. ilicifolius*, and (c–e) *Sc. soldanelloides* var. *minimus*.

As described in Yamazaki (1968), the plants on Yakushima can grow in rocky area (personal observation). However, since both *Schizocodon soldanelloides* and *Sc. ilicifolius* may also grow in rocky areas (personal observation), this habitat feature is not helpful.

We therefore see no reason to classify the plants on Yakushima as a variety of *Schizocodon ilicifolius* on the basis of morphology and habitat. Instead, we recognize the Yakushima plants as *Sc. soldanelloides* based on the shape of the leaf serrations and the apex of the staminodes. The dwarf form did not change in stature under cultivation at room temperature throughout the year (personal observation). We therefore agree that these plants should be treated as *Sc. soldanelloides* Siebold et Zucc. var. *minimus* (Makino) H. Hara.

Makino designated a specimen collected on Mt. Miyanoura on Yakushima in 1909 as the type of *Shortia soldanelloides* (Siebold et Zucc.) Makino f. b. *minima* Makino, giving the locations as Prov. Osumi: Mt. Miyanoura-dake in Isl. Yakushima (Sept. 1909, *T. Makino* !). We were unable to find a specimen matching those details in MAK, TI, MBK, TNS, or KYO, suggesting that it has been lost since Makino's report (1912),

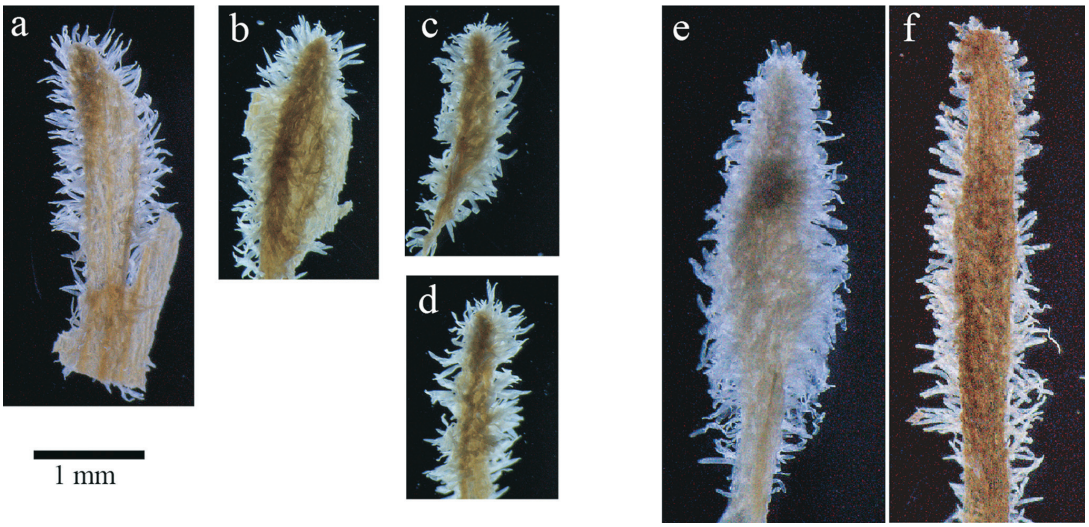

FIG. 2. Staminoid shape in *Schizocodon soldanelloides* var. *minimus* (a–d), *Sc. soldanelloides* var. *soldanelloides* (e), and *Sc. ilicifolius* (f).

thus requiring designation of a lectotype.

Schizocodon soldanelloides Siebold et Zucc. var. **minimus** (Makino) H.Hara, Enum. Sperm. Jap. 1: 72 (1948).

Basionym: *Shortia soldanelloides* (Siebold et Zucc.) Makino f. b. *minima* Makino in Bot. Mag. Tokyo 26: 28 (1912). - *Shortia soldanelloides* (Siebold et Zucc.) Makino var. *minima* (Makino) Masam. in [Prel. Rep. 107 (1929)] Bot. Mag. Tokyo 44: 221 (1930). - *Shortia yakusimensis* (Siebold et Zucc.) Masam. in J. Trop. Agr. 4: 193 (1932). - *Schizocodon soldanelloides* Siebold et Zucc. f. *minima* (Makino) Honda in Nom. Pl. Jap. p.253 & 516 (1939). - *Schizocodon ilicifolius* Maxim. var. *minimus* (Makino) T.Yamaz. in J. Jap. Bot. 43: 81 (1968).

Typus. Japan, Miyanoura-dake in Yakushima, Sep. 1909, *T. Makino* s.n, not seen.

Japanese name. Hime-koiwakagami (Makino 1912)

Distribution. Endemic to Yakushima Island.

Specimens examined. JAPAN. KAGOSHIMA: Mt. Kuromi, *J. Haginiwa 20704* (TNS); Mt. Kuromi, *H. Okada & A. Takahashi 3047* (TNS); Mt. Miyanoura, *H. Okada & A. Takahashi 3066* (TNS); Mt. Kuromi, *J. Haginiwa 20674* (TNS); *H. Koidzumi 227* (TNS); Yakushima, Aug. 1913, *Y. Yoshii* (TNS); Mt. Miyanoura, 2 Aug. 1930, *K. Naohara* (TNS); Yakushima, *T. Nagao 39293* (TNS); Mt. Miyanoura, *T. Yamazaki, H. Ohba, J. Murata & S. Akiyama 2130* (TI); Mt. Miyanoura, *T. Yahara, T. Nagamasu & T. Kawahara 10386* (TI); Mt. Miyanoura, 7 Aug. 1961, *Suzuki, Yamazaki & Usui* (TI); Mt. Kuromi, 26 Aug. 1963, *T. Yamazaki* (TI); Mt. Miyanoura, *T. Yahara, J. Murata, M. Kato, N. Murakami & students 6013* (TI); Yakushima, *Y. Yoshii* (TI); Mt. Miyanoura, *Y. Kimura 39165* (TI); Mt. Kuromi, *H. Setoguchi JP2429* (KYO); Mt Miyanoura, *M. Tagawa 1929* (KYO); Mt. Kuromi, *H. Okada & A. Takahashi 3047* (KYO); Mt. Miyanoura, *G. Murata & H. Tabata 453* (KYO); Mt. Miyanoura, 8 July 1918, *K. Yamaguchi & T. Nagao* (KYO); Mt. Miyanoura, *K. Shimizu 81-365* (KYO)

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